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DEVELOPMENT OF ELECTRONICS

IN

TANZANIA*

prepared by

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1. INTRODUCTION

Under normal circumstances, the mechanical and electrical engineering industries are fairly closely linked. Originally mechanical equipment was either manually operated and powered or driven by some simple natural process, for example water or animal power (e.g. water pumps). With the introduction of electric power, this was immediately adopted for powering the machine. This led to the development of electro-mechanical technologies. However because of the requirements for greater quality control, mass production and economies of scale, there has been an increasing tendency to replace mechanical parts by electrical parts.

Now, since 1970, there has been a rapid tendency to replace electrical parts with electronic parts. In the 1980s simple analogue electronic parts will be replaced by digital electronic parts and complex micro-processor equipment. To some extent, electrical engineering is replacing mechanical engineering in the development world and Tanzania will shortly inherit this trend too. Electrical engineering is therefore the "cutting edge" of mechanical engineering technology and should be viewed as a natural chronological development of the mechanical engineering industry.

For the case of Tanzania, electrical energy and equipment is employed in four main sectors as follows:

- Energy generation and distribution
- Industrial Development
- Telecommunications and Radio
- Domestic and Services sector.

However, Tanzania has experienced an acute shortage of trained manpower and repair facilities for new and complicated electric and electronic equipment now being increasingly introduced in Government Organizations and private industry. Another major problem is that there is a very great diversity of equipment and its applications in Tanzania and the difficulties encountered in trying to

determine the amount and type of equipment in use in Tanzania today. There are more than 800 industrial concerns employing more than 10 persons in Tanzania today. Virtually all of these use electrical energy and electrical/electronic equipment in various forms as the equipment have been imported from very many sources. Some industries use very old and simple British electrical equipment, others have imported the latest Italian process equipment, many use Japanese Components, others employ East European electronic parts.

These problems make it difficult to forecast both the size of demand for electrical/electronic repairs and maintenance services and the type of demand. The same problem applies to determining what types of electrical industrial production is appropriate to Tanzania today. The dynamic development in industrial design in developed countries from which Tanzania imports most of its electrical and industrial equipment make it similarly very difficult to forecast trends in the demand for repair and maintenance.

The importation of micro-electronics (Integrated Circuits) equipment in Tanzania is just at its early stage and from this basis, this report tries to reveal the present position and the use of electrical/electronic parts in Tanzania. Efforts on the attempts to manufacture locally some of the components are also discussed with a major recommendation of establishing a National Repair and Maintenance Centre so as to increase the life time of the machines and equipment we have.

2. TANZANIA's INDUSTRIALISATION STRATEGY

The basic structure of the manufacturing economy in Tanzania is still a reflection of Tanzania's Colonial history and the predominance of agriculture in the overall economy. However, there has been a clear qualitative change in methods of production and in production itself since the early years of independence State intervention in e.g. textiles, leather goods, chemicals and metal industries has implied heavy investment in these sectors and in production of equipment and plant. This in turn, has had a marked effect upon the demand for electrical energy in industry.

Tanzania's policies for industrialisation can be summarized in the following main points in order to see the logic in the overall industrialisation process.

– Tanzania's electrical power resources are being extended rapidly both to produce more power and to distribute power to rapidly industrialising areas e.g. Mwanza, Mbeya and Kilimanjaro. As 62% of the power consumed today in Tanzania is utilised by industry, such a development is essential.

- Basic energy sources e.g. Coal are to be developed at Liganga in order to fuel the basic iron and steel industry. This may also be supported by hydropower from Stiegler's Gorge.
- Basic energy sources e.g. Coal and hydropower are to be built up to reduce Tanzania's crippling dependence on imported overseas oils.
- Tanzania is proposing to produce 300,000 to 500,000 tonnes of steel per annum using its own energy and raw material resources. Steel is one of the "basic building blocks" of machine industry whether it be mechanical or electrical.
- Tanzania has already established several metal fabrication industries which are essential for machine manufacture e.g. Aluminium Africa, Tanga Steel Rolling Mills etc.
- Tanzania was proposing to develop petrochemicals and possibly PVC production and this may be promoted by the development of the Songo-Songo gas field.

  These materials are also very important in the development of mechanical and electrical engineering production.
- Tanzania has already developed a wide variety of consumer industries producing for the domestic market and these are saving valuable foreign exchange.

There is thus little doubt that Tanzania has the basic elements and manufacturing inputs for a mechanical/electrical engineering industry in terms of raw materials, steels, aluminium, plastics and energy from various different sources. In addition the country is developing its manpower resources through numerous University, College and vocational training courses in electrical engineering. The

groundwork for the development of an electrical engineering strategy is therefore in place in Tanzania.

Industrialisation policy in Tanzania therefore visualises a substantial shift in structure from a processing economy to one capable of producing the means of production and basic raw materials, e.g. iron, steel, processed metals, petrochemicals etc. These industrialisation policies will increase demand for electrical and electronic equipment in industry enormously. Industry will grow both in size and in the scale of intensity of electrical equipment. However, as it is not known today how much such equipment is used in industrial production, it is difficult to make any reasonable forecasts of future use.

3. PRESENT OBSERVATIONS:

3.1 THE INDUSTRY SECTOR: The following observations can be made from various industries in Tanzania:

- Machinery came from a large number of different producers in many different countries e.g. Japan, UK, USA, Italy, France, Belgium, Sweden, Norway, Finland, Holland, Bulgaria, India, Pakistan, the Federal Republic of Germany, Yugoslavia, Denmark etc.
- A considerable amount of multi-operational machinery, based on flow-line production principles had already been introduced and this tendency is increasing.
- Much industrial production machinery which previously had mechanical regulating controls is now fitted with electronic controls.
- Electronic fault-finding is becoming a problem with much industrial production machinery.
- Shortages of spare parts (especially electronics) affects most establishments but not all.
- Re-winding of motors is a problem with some of the older machinery.
- Older well established firms with simple mechanical equipment have relatively few machinery problems.
- Lack of proper instrumentation is a constant problem throughout the industries.

- Fluctuations in voltage in the public electrical supply system is causing substantial problems throughout the country, especially for delicate electronic equipment.
- It is difficult to obtain appropriately designed production machinery for Tanzanian Conditions, - most of this type is now out of stock. If it is obtainable, e.g. UK machines, it is very expensive.
- Changes in design of different models of machinery in Europe had an impact in Tanzania because of the discontinuation of particular lines of spare parts.

The diversity of suppliers of electrical production equipment is also becoming a problem. Tanzania is frequently obliged to buy from countries and suppliers which can offer the best credit facilities. This accounts for the very wide diversity of equipment in the country. This makes the interchangeability of parts very difficult and the standardisation of parts even more difficult. If one country can offer suitable financial terms for a particular industrial production process, it is very tempting to select this process whether Tanzania has trained technicians or equipment to operate and repair it or not. This is a difficult problem which is likely to increase in the future.

TECHNOLOGICAL AND DEVELOPMENT TRENDS:

It seems likely that the content of electronic equipment in machinery imported in Tanzania will increase faster than the actual amount of machinery imported. This is because the proportion of electronic equipment in industrial production machinery is rising rapidly in the industrialised countries which export machinery to Tanzania. The development of prices of electronic components are making it more and more economic to include more and more electronic components in industrial process machinery in the industrialised countries and this is where Tanzania obtains its machinery.

There is thus little doubt that industrial production equipment imported into Tanzania in the future will contain a higher content of electronic components than previously. Indeed, if importing from the industrialised countries it may well be impossible to import equipment without electronic equipment.

3.2 THE SERVICES SECTOR

By the "Services Sector", I mean electrical equipment which is used for domestic purposes, i.e. consumer electrics and electronics, e.g. radios, cookers, ovens, hot plates, water heaters and other domestic appliances and fittings e.g. domestic switches, low-voltage switchgear and fuses etc. The terms also covers Social and Economic Infrastructure, i.e. the electrical equipment required in the tertiary services sector of the economy, i.e. hospitals and health services, Universities and education and other public sector services, water supply and agriculture e.g. irrigation pumps etc.

Tanzania has a very limited production in this sector, and it is limited to the assembly of radios by National (Matsushita) in Dar es Salaam and by Philips in Arusha, and to the assembly of fuse-boxes and smaller switch-gear by Northern Electrical Manufacturers in Arusha.

Apart from the assembly and further production of mass consumer goods like radios, the production of domestic consumer electric goods would not seem to be a national priority at the moment, because of the luxury aspect of the product. This, of course, does not apply to the production of domestic low-voltage switchgear and fittings which is a very different type of product in a rural electrification programme.

DEVELOPMENT TRENDS

The growth in consumer electrics and electronics is likely to take place most in the radio and cheap domestic appliance sector. Other, more expensive consumer goods, e.g. refrigerators, air-conditioning systems etc. are likely to grow more slowly and cannot be regarded as a priority in today's economic development. Domestic and low-voltage switchgear is growing in demand, and there may be scope for limited production in Tanzania to substitute for imports. Repair and maintenance of these

items seems adequately covered by the commercial sector.

DIVERSITY PROBLEM

As stated earlier, this is a very diverse sector including health and hospital sectors, Universities and schools and other public sector operations. This sector is characterised by the use of fairly simple electrical and electro-mechanical equipment e.g. water pumps, irrigation equipment, low-voltage equipment for public buildings etc. It is not known to any degree the extent of the use of electrical equipment in social and economic infrastructure, but little of it is very difficult to repair or maintain and there are already several institutions like the Ministry of Communications and Works and the Ministry of Water, Minerals and Energy who maintain their own workshops.

3.3 THE TELECOMMUNICATIONS SECTOR

The use of telecommunications in Tanzania is very widespread and and is to be expected in such a large country. The main users of such equipment include: Posts and Telecommunications Department, Extelcoms (external telephone, cable, radio links), Tanesco, Directorate of Meteorology, Directorate of Civil Aviation, Radio Tanzania, Air Tanzania, Police Signals Office, Tanzania Railways Corporation, Tanzania Harbours Authority, Aeradio Tanzania Limited, Tanzania Cotton Authority, some ranching schemes, prisons etc.

DEVELOPMENT TRENDS

New more effective types of electronic equipment, components and technical parts are arriving on the market at steadily lower prices. The micro-processor which can be described as a "Computer in miniature" will, in future, be one of the most important parts of the telecommunications equipment which is on offer to Tanzania. Future telecommunications technology will be based on Computer technology. Full use of computer technology's possibilities assumes that Communications signals will be sent in the form of data - or as it is often termed - "digitally".

The main features of the technological development within telecommunications in the developed world (which will thereby have a profound effect on what is available to Tanzania) are the following:

- use of Semi-Conductors and microelectronics;
- use of computer technology and digital communications technology;
- telecommunications satellite technology;
- use of fibre optics (laser technology).

The introduction of such new technologies will give considerable financial savings in the following fields:

- greater capacity per system unit;
- lower costs per capacity unit;
- greater reliability;
- lower operations and maintenance costs;
- a volumetric reduction in equipment and thereby the overall need for buildings to house such equipment.

The trends described above will obviously have their impact on Tanzania who import almost 100 per cent of their telecommunications equipment from these countries where such changes are taking place. Tanzania will therefore automatically import the new technologies and their specialised needs for repair and maintenance.

4. IMPORTATION OF ELECTRICAL SPARE PARTS

Maintaining adequate standards of repair and maintenance in energy supply, telecommunications, industry and the service sector is totally dependent on the continuous and uninterrupted supplies of electrical and electronic spare parts. However, it should be recalled that, apart from the assembly of components, Tanzania has no electronics production to-day.

Imported spare parts are available in Tanzania through three different channels as follows:

- the state purchasing organisations of BHESCO, AISCO and DABCO.
- private import by individual companies (most usual method).
- import to foreign-assisted projects through credits or grants.

In future, this is in fact not our main goal as Tanzania, in its industrialisation process, must use electrical equipment. Thereby it must reduce its dependence on overseas and develop its own capabilities for repair, maintenance, part and machine production.

Given Tanzania's shortage of foreign currency to import electrical spare parts , it is tempting to consider production of spare parts as part of an import substitution programme. It is clear that, if Tanzania is to industrialise, something must be done to improve the spare parts situation, and in order to keep the thousands of new machines which will be imported in the next 20 years, running. Three actions seem possible.

These are:

- to produce more electrical spare parts in Tanzania;
- to gear purchasing policy of machinery much more towards standardisation and interchangeability of spare parts.
- to set even higher priority on the import of spare parts and to develop a "spare parts bank" in Tanzania.

5. PRODUCTION OF SPARE PARTS

The primary objective of a strategy for the Electrical and Electronics Industry in Tanzania must be to make the country as self-sufficient as possible in the production of electrical equipment, production of spare parts and repair and maintenance of equipment, as is technologically possible. This means developing a strategy to build an industry which is not indigenous to Tanzania. Such a strategy is already implicit in Tanzania's long-term development plans and frequent mention is made of "establishing basic industries" in the Ministry of Industries and Trade's various policy statements on the development of the Metals and Engineering Sectors.

The purpose in developing the engineering sectors in general is to give Tanzania the capacity to produce its own capital goods equipment i.e. equipment which can produce goods and equipment which can produce other machines. Until Tanzania is capable of this it will also be at the mercy of outside forces and outside suppliers.

As far as electronic spare parts are concerned, there is no production in Tanzania as yet. This is the same story even in the industrialised world where you find few countries are completely self-sufficient on electronic spare parts. For the case of Tanzania the production of electronic spare parts is hindered by a number of reasons as follows:-

- the economies of scale in component production are

completely different from those in mechanical component production. Production requires very large runs and on intercontinental market. It also requires an active research and development engineering environment.

- Tanzania has imported electronic equipment of very many different origins and nationalities. It is difficult to standardise electronic parts and to interchange components. Demand for individual types of components are thus very small and hardly economic to produce.
- There are probably insufficient trained personnel to operate such production.

PRESENT CAPABILITY

The only industry producing electrical spare parts is the Tanzania Cables Limited of Dar es Salaam. This Company produces electrical wiring of all types including domestic wiring low tension transmission wires up to 1KV, enamelled wires up to 42 grade, aluminium conductors and overhead conductors and copper cables and copper enamelled wires. It was hoped to expand production into telephone cable, PVC wire, domestic switches, auto-wiring and small motors.

It is very clear that Tanzania Cables production of spare parts is of vital importance to Tanzanian industry, electricity generation and telecommunications and can form the basis of industrial production of electrical spare parts.

Northern Electrical Manufacturers (NEM) in Arusha are a promising venture, hoping to develop electrical production for the domestic market. They already produce fuse boxes with materials imported from Sweden and Norway and cable boxes and aluminium cable ducts, using materials from Aluminium Africa in Dar es Salaam. They also intend to start producing Ceramic fuses from local materials.

Because TANESCO's demands for spare parts is extremely high and largely dependent on the import of parts, attempts have been made to produce parts in the TANESCO workshops e.g. cross arms, shackle straps, earth and galvanised masts, earth rods, boards etc. However, spare parts for purely electrical or electronic machines cannot be produced by TANESCO. The complexity

of products like electric and electronic relays, inverters and regulators make it difficult to produce such capital intensive products in small runs.

Also, there have been discussions in Tanzania on the production of small motors for industrial purposes. It appears that Tanzania Cables is considering small motor production in the near future and PEMACCO in Mbeya has established a motor re-winding and assembly shop with a view to developing motor manufacture at a later stage.

5.1 SERVICES SECTOR

As mentioned before, the services sector is a very diffuse one including domestic and consumer electrics, and social and economic infrastructure i.e. all electrical equipment used in the health, education and other public sectors.

The repair and service of consumer electrical and electronic goods are, as in other countries, undertaken by a great many small, privately - owned workshops in Tanzania. These belong largely to the informal sector and are concentrated in Dar es Salaam where the market is largest.

The basic raw materials for the manufacture of domestic electrical equipment i.e. ceramics, plastic, aluminium etc. are already available in Tanzania, and at least one industry Northern Electrical Manufacturers of Arusha has already started production of simpler equipment. The scope for production in this sector appears therefore to be:-

- Screw fuses of all types;
- Domestic ceramic insulators;
- plastic plugs and sockets;
- Domestic insulated wire;
- Wall outlets.

PROBLEM:

The electrical equipment content of the services sector is so diffuse and the requirements for personnel and equipment and training are so diffuse that it would be extremely difficult to centralise repair and maintenance facilities. It also appears that most institutions in this sector are trying to develop their own

specialised repair capacity by developing their own sectoral workshops. It would be extremely difficult and very costly to develop a repair centre for both railway telecommunications equipment and hospital equipment as the technologies and specialisms are so different.

5.2 ENERGY SECTOR

The following products seem to be necessary and possible to produce in Tanzania:

- Insulators of all types;
- Mechanical hardware for transmission lines;
- Kilowatt Hour meters;
- Small AC - motors;
- Spare parts for generator and motor rewinding e.g. coils, brushes, varnishes etc.;
- High and low voltage fuses;
- Power voltage regulators;
- Electronic voltage regulators;
- Batteries (are already produced in Tanzania by National in Dar es Salaam);
- Power supplies.

5.3 INDUSTRY SECTOR

The structure of manufacturing industry in Tanzania is typical of many other developing countries in Africa. It is characterised by a concentration on the processing of natural resources which constitute about 70 per cent of the value of production.

PROBLEM

As far as electronic component production is concerned, it seems rather unlikely that Tanzania could embark on production in this field for the reasons below:

- the international free trade character of the market;
- the need for an active research and development environment;
- the relatively small internal market in Tanzania;
- the concentration of to-day's production in a few highly competitive nations in South -East Asia.
- the high investment required in tooling and production equipment.

RECOMMENDATION

Certain simpler components, however, could probably be manufactured in Tanzania and these include the following:

- Assembly and duplication of printed circuit boards;
- Moving and fixed contacts for starters;
- Transformer winding coils;
- Insulators of all types;
- Single and multicontact relays;
- Fuses of all types;
- Kilowatt Hour meters;
- Switches;
- Plugs and sockets;
- Insulated wire.

There is already a basis for production in Tanzania for most of these components, either in the metal working industry or the electrical machinery industry. However, feasibility studies of these components should be carried out.

5.4 TELECOMMUNICATIONS SECTOR

The electrical and electronic technology employed in the telecommunications sector is generally more advanced than in other sectors so that it is more difficult to recommend components for production in Tanzania which do not involve advanced electronics. However, many components in the telecommunications sector are common to other sectors and the main needs for parts production in this sector are found to be the following:

- mechanical and electronic relays of all types;
- transformers;
- power generating sets;
- coin boxes;
- rectifiers;
- Voltage stabilisers.

It is recommended that the production of the following components will be of value to the sector:

- carbon film resistors of all denominations;
- polyster type capacitors;
- power resistors;

However, feasibility studies should be carried out before the production of these elements, in combination with studies done for the other sectors.

5.5 PRIORITY PRODUCTION SECTORS

It has already been indicated in this paper that there are approximately 20 components spare parts within the electrical industry which could possibly be manufactured in Tanzania drawing on all sectors for their market. It is recommended that priority be given to the following parts because of their potential and because of the critical need for these in Tanzania:

- Mechanical hardware for the energy sector;
- Simple meters;
- Domestic and household switchgear;
- Fuses;
- Insulators;
- Small AC-motors.

All these components would assist the development of the electrical industry in Tanzania and assist in developing an "electrical environment" which does not exist to-day.

6.0 REPAIR AND MAINTENANCE

More and more manufacturers of production equipment in the developed countries from which Tanzania gets the bulk of its equipment are moving towards electronically controlled process equipment. Such equipment is simple to maintain and repair in an economy where there is an easy international interchange of know-how parts and components. This is not so easy in Tanzania where there is currently a premium on foreign exchange. By importing advanced electronically controlled production equipment, Tanzania is being pulled into an international market place of which it is not fully a part and where it has the lowest order of priority.

Tanzania's policies for industrialisation over the next 20 years will naturally have a very strong bearing upon the need for maintenance and repair facilities for electrical and electronic equipment. Both the future size and the future structure of industry will affect this need. The Fourth Five Year Plan (1981-1986) estimates

that the manufacturing industry sector will grow at between 7-9% per annum.

Some of the Government and private users of sophisticated electronic technology have been experiencing problems in the way that expertise and spare parts for repair and maintenance have not been available.

Attitudes to the importance of maintenance and repair of all equipment (not only electrical) vary enormously from sector to sector and from individual production unit to individual production unit.

In Tanzania, the repair and maintenance sector generally has a low status, as in most countries. This may be a feature of Tanzanian society inherited from earlier times. However, with the shortage of trained engineers in Tanzania today, it is much more tempting for the graduate to move into the fields of production and research and development rather than maintenance and repair. The former field is much more interesting in itself and it is usually better paid. This is one attitude which may have to change. In its present economic situation, Tanzania simply cannot afford to down-grade maintenance and repair of productive equipment.

6.1 SERVICE SECTOR

As to repair and maintenance of domestic electrical equipment, there appear to be adequate facilities in most towns in Tanzania. Dar es Salaam contains numerous workshops specialising in the repair of domestic electrical equipment, as this is an attractive commercial market for most small entrepreneurs, and the market is well covered.

6.2 TELECOMMUNICATIONS SECTOR

Repair and maintenance efforts in the telecommunications sector, encounters various problems particularly in the following field:

- lack of spare parts, especially electronics;
- lack of tecnical staff;
- lack of trained technicians and lack of training;
- problems with environment (voltage fluctuation etc.)
- assistance needed on instrument repair/calibration.

The maintenance and repair of telecommunications systems is known to be a complex problem, - much more than in developing a new project. What is more, unlike the development of a new system, which may take only a couple of years, maintenance and repair calls for a lower key, but nonetheless sustained and prolonged effort.

In the modern world, there is an increasing complexity of electronic equipment and technologies which are steadily coming on offer on the internationdl telecommunications market. This is a tendency over which Tanzania has very little control. However, as stated above, the country should endeavour to maximise the use of that equipment it already possesses.

6.3 INDUSTRY SECTOR

The following conclusions can be drawn in examining the maintenance and repair facilities in Tanzania industries:

- Most industries have tried to establish electrical/electronic workshops to repair and maintain production equipment;
- Some industries have little or no electrically qualified staff for electrical/electronic repairs e.g. qualified graduate engineers;
- There is a general shortage of experienced and trained electricians and electronics technicians throughout the industry;
- Lack of spare parts is a recurrent problem throughout industry;
- There is very little fault - finding equipment e.g. oscilloscopes available for electronics repairs;
- Most electronics repairs are very difficult either because of lack of equipment and/or experience. There is no production of electronic spare parts in Tanzania;
- Much electronics equipment is either sent to private workshops in Dar es Salaam or abroad to the suppliers for repair;
- There is a very great need for competence in instrument repair/ calibration;
- Tanzania is facing serious foreign exchange difficulties because of factors beyong its control;
- The changes in industrial structure are leading to an increasing use of electrical energy and thereby electrical equipment in Tanzanian industry;

- Industrial location in Tanzania is strongly influenced by the availability of electric power, i.e. in the coastal region and Lake region. Industry is the principal user of electric power in Tanzania, so that its distribution will affect the distribution of electric power;
- The electrical and electronics sectors seem to be highly dependent on non-citizens, so that the country is highly dependent on non-citizens to keep its industry running as technologies become more and more complicated;
- Tanzanian industry has a reasonable capacity for the repair of electro-mechanical equipment, power supply (transformers, switchgear, cables and distribution pannels etc) and the rewinding of small motors;

All of these factors point to an increasing sophistication of Tanzanian industry and consequently further electrification and use of electrical equipment. At the same time, difficulties with foreign exchange will make it increasingly difficult to carry through this electrification of Tanzanian industry. A basic principle of Tanzanian industrial policy must therefore be to prolong the working life of electrical production equipment so as to maximise the benefits of investment in a scarce imported production unit. This makes effective repair and maintenance of electrical production equipment in industry an absolute necessity in pursuing national industrialisation policies.

The availability of spare parts, fault-finding equipment and the import of new equipment are all closely related. Because decisions to import new industrial process equipment are not usually taken by the people who will have to repair it, and because more and more imported equipment is electronic, the development of electronics workshops and the appropriate fault-finding tools will certainly lag behind the import of machinery. This in turn, will generate a larger demand for spares, - where it proves impossible to find faults and to repair. This combined with a lack of specialised manpower will make it doubly difficult to develop electronic workshops.

7. TRAINING FACILITIES FOR ELECTRICAL/ELECTRONICS ENGINEERING

The following are the main sources of training available to electrical/electronics/telecommunication engineers and technicians:

- Overseas courses with universities colleges or suppliers;
- Kidatu Technical College (TANESCO);
- Dar es Salaam Technical College;
- Dar es Salaam Vocational Training Centre;
- Arusha Technical College;
- University of Dar es Salaam;
- High Precision Technology Centre;
- Posts and Telecommunications Training Centre.

The training abroad is generally paid for by the supplier and Tanzania should insist that this is done every time a new piece of major equipment is to be commissioned.

TWO PROBLEMS

The first is the background of many of the students. Most students should first obtain some practical experience before starting courses unless the students are to become too theoretical. A second problem is that there is still probably insufficient advanced electronic equipment available in individual industries to give graduate engineers practical on-the-job training. This is particularly true of digital electronics which is not yet present in any degree but which will come in quickly.

8.0 FEASIBILITY STUDIES

It is recommended that feasibility studies be undertaken on the production of certain basic spare parts. The purpose of these studies would be to ascertain the financial and economic viability of production and to develop the basis for an electrical manufacturing industry in Tanzania. Feasibility studies should be carried out into the production of the following components/parts:

- Fuses of all types;
- insulators of all types;
- plugs, sockets and switches
- Low voltage Voltage Regulators;
- Mechanical/Electromechanical parts for the energy sector;
- Simple meters;
- Domestic and low voltage switchgear;

- Single and multi-contact relays;
- Small AC-motors.

9.0 RESEARCH AND DEVELOPMENT

However, because of Tanzania's peculiar situation in relation to technology in the developed countries, it may also be appropriate to concentrate more attention on research and development. In all developed countries, research and development takes place before production. Maintenance and repair routines are often worked out in parallel with research and development processes so that maintenance and repair facilities and capability is in place when the first machines come off the production line.

In Tanzania production is taking place on the basis of research and development undertaken in other countries for other purposes and for other environments. To some extent then, Tanzania is beginning to produce and certainly to import before any appropriate research and development. Any research and development of the appropriateness of technology is taking place after the import or production of the part. This, of course, means that repair and maintenance routines are not appropriate or in place and have to be improvised.

10.0 AN INSTRUMENT BANK

Many of the Tanzanian industries have very considerable problems with instruments. Either they have no instruments at all, because their use for them is so limited that it will be uneconomic to purchase them. Or they have them but they have serious problems in their operation, repair and maintenance. In such a situation it would seem logical to rent (from a national body), rather than to own such advanced equipment for the periods it is required.

11.0 RECOMMENDATIONS AND CONCLUSION

Since the electrical/electronic equipment are inevitably used in various sectors such as industry, energy, telecommunications and service and since these sectors represent an essential function within the economy of Tanzania, it is clear that a requirement exists for the establishment of:

- Centralised facilities for electrical/electronics repair and maintenance service within Tanzanian industry.
- Undertakings to manufacture selected electronic and electrical compqnents which have been suggested in this paper when found technologically and economically viable.

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Getachew Degefu**

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1. Background Information

Ethiopia is one of the developing countries of Africa with an area of about 1.2 million square kilometres and a population of some 42 million inhabitants. The economy is predominantly agrarian with the manufacturing sector contributing a mere 5 per cent to the GDP. Even though the agricultural sector is still considered as the base of the economy and hence accorded a paramount importance, the country has been endeavouring, especially since 1974, to import structural transformation in her economy and enhance the industrial sector. This is evident in the increasing contribution of the manufacturing sector in the past years, and in the fact that the industrial sector has been given the "leading role" in the country's recently drafted 10-year indicative plan.

Within the industrial sector particular emphasis is given to the development of engineering industries in which electronic industries form a good part.

Electronics is a high technology modern science and industry that has gone through dramatic changes and growth, especially in the post-war era, now encompassing practically the whole facet of modern living. It now influences modern economics both in the developing and developed worlds in the areas of defence, communication, broadcasting, public health, education, industry, business, atomic energy, entertainment, environmental control, space technology etc. The degree of influence in a particular area, however, varies with the general level of development of the country. In Ethiopia, for example, the country being in the lower ranks of development, electronics finds more applications in the areas of telecommunication, broadcasting and, to some extent, in entertainment, public health, defence and business areas. Production in the electronics sector has not yet started in Ethiopia, but it is time that such activities started at least by assembling imported kits and components to make such basic and broadly needed electronic items like radio, TV etc. The Government of Ethiopia has already realized this and serious considerations are currently being undertaken to survey the sub-sector and formulate such a project.

2. Status of the Electronic Sub-Sector

As indicated earlier, electronics has not yet started as an industrial activity in Ethiopia though some experimental trials towards assembling certain electronic equipment like radio etc. have been noted. The use of electronics, however, like in many other developing countries, started some 50 years back with the mass communication sub-sector, and one finds sophisticated systems in operation in the field of mass media (radio and TV), radio communication, telecommunication, navigational aids for civilization and data-processing.

2.1 Mass-Media

One of the earliest usages of electronics in Ethiopia was in radio broadcasting. Today broadcasts are made in three international and six national languages through studios in Addis Ababa, Asmara and Harar. The broadcasting transmitters range from 1-200 kw covering MW and SW bands. There are plans by the Government to modernize and expand not only the transmitting stations, but also increase the number of languages of transmissions so as to cover the entire population of the country.

Television transmission started in Ethiopia in the year 1964 with monochrome transmission in Addis Ababa, and today it has grown to cover a number of regional stations (Asmara, Diredawa, Jima etc.) connected through microwave links. Colour transmission has recently been introduced and there are ambitious plans to establish a number for transmitting stations along microwave routes, establish community receiving centres and expand present coverage by about 20 times. Ethiopia has an earth station capable of receiving international TV transmissions.

Radio and TV are now extensively used to transmit formal and non-formal education. In fact there is a unit, under the Ministry of Education, running some 11-1 kw transmitters scattered all around the country solely for this purpose.

2.2 Communications

Telecommunications were introduced to Ethiopia as early as the end of the 19th century. The manual and electro-mechanical exchanges yielding to electronics switching systems, telecommunication has become more and more electronics throughout the years. In Ethiopia, telecommunication has grown quite considerably, especially in the last 30 years, now employing some 113,000 auto and manual direct exchange lines, PBAXs, microwave links and a satellite earth station. The microwave links cover some 4,000 route kilometres. This includes the PANAFTEL link of the Shashemene/Moyale extension to Nairobi and the international surface link Assab/Djibouti. There are plans to expand the routes within the country (1,500 routes) to cover remaining important towns and also complete the PANAFTEL link with Gedariff (Sudan). The standard 'A' earth station accessing AOR primary satellite presently uses some sixty-one circuits out of which one only is an AVB data circuit and seven are record bearer circuits. The number of circuits in use is expected to rise to 1,112 in the next five years. There are also plans to set up a standard 'B' earth station accessing IOR traffic and also to introduce digital switching.

Radio communication is widely applied for more specialized (localized) communication purposes. This covers products like HF, VHF and UHF transreceivers, fixed as well as mobile and hand-held. They are finding increasing use in police and security services, airport, state farms, mining, construction activities etc. Radio communication contributes greatly, especially in developing countries like Ethiopia where there is a lack of adequately developed roads and other line communication facilities.

2.3 Industrial applications

Industrial establishments in Ethiopia, mostly being old and technologically backward, make little use of electronics applications. In the industrialized countries, the industrial sector is experiencing practically a revolution through the applications of power electronics and microelectronics in the instrumentation, control and management, automation and robotization of huge industrial enterprises. Ethiopia has yet a lot to do to benefit from this area.

2.4 Business Application, Computing and Data Processing

This is an area in which microelectronics finds great application, not only in the developed countries but also in developing countries like Ethiopia. Electronic calculators and cash registers have practically replaced the obsolete slide rule and mechanical calculators. Mini- and large-frame computers are finding wider application in business organizations, banks, hotels, engineering organizations and universities. They are mostly used in computing recording, posting, billing, pay-roll and inventory control. Applications in other areas of management are also being introduced. The Ethiopian Airlines, for example, makes use of modern computers in ticketing, programming, maintenance management, airport management etc.

3. Market and Demand for Electronics Products

One can see from the above indications that, despite the low level of economic development, Ethiopia makes use of a wide range of electronic products in her endeavour to modernize her economy, enhance the standard of living of the people and keep pace with the fast changing but intricately interdependent modern world. A substantial amount of yearly expenditure is spent to import electronic product. This can be seen from Table 1 showing the import figures of electronic products for the years 1977-1980. The decreasing total annual value of the imports does not show a decrease in the actual demand for electronic products. This happened due to the political and economic complications following 1974 and the recurrent shortages in foreign exchange vis-a-vis the country's endeavour to allocate her meagre resources to more basic and necessary commodities.

Although the demand for a particular electronic product is still generally too low to justify local production, it is sure to rise with the economic development of the country and the standard of living of the population. A recent demand projection for selected consumer electronic items shown in Table 2 could serve as a conservative indication of this trend.

Electronic products cover a wide variety and are fast changing. It is obvious that no developing country can satisfy its yearly demand purely by importing. An in-house capability for production has to be started somehow and encouraged so as to gradually compensate for more and more of the import requirements.

4. The Electronic Industry - Techno-Economic Characteristics

It has been repeatedly pointed out that the electronic industry is characterized by fast changes and a high rate of obsolescence, both in the production and application areas. It has changed in less than half a century from vacuum tubes to transistors and finally to microelectronics whose technological sophistication, miniaturization and field of application is increasing at astounding rates. This characteristic of the industry might make it difficult for developing countries like Ethiopia to start their own industry.

The electronic industry has, however, other characteristics, which make it particularly interesting from the point of view of developing countries: high growth rate/growing market; impact on every sector of the economy; increase of productivity in industries; elasticity in its employment levels; location independent; export oriented; use of products is already introduced; high intersectoral linkages; high flexibility of production facilities.

The above characteristics of the electronic industry, its relatively low capital intensity requirement and higher output to capital ratios make it attractive and useful for developing countries like Ethiopia to start and develop their own electronic industry as early as possible. The question is now to what extent and how.

5. Development Policies and Strategies

Many electronic products are highly sophisticated and are required in relatively smaller quantities especially in developing countries. Their production, on the other hand, is more capital intensive and technology

intensive. Hence even the more developed countries still depend on other highly industrialized countries for the supply, installation and even maintenance of this sophisticated equipment. On the other hand, there are quite a number of electronic products required in large numbers and for mass consumption, like radio, TV receivers, telephone apparatus, calculators etc., which are relatively simple in construction. Developing countries usually start industrial activities in the electronic sub-sector with assembly of such products. With growing competence, the forward integration of component production and development of new design continue.

Various strategies might be pursued for the development of electronic industries in developing countries as far as the market and technological transfer requirements are concerned. In many African countries, the market even for consumer electronics is limited because of low per capita income rather than size of population. But this problem could be solved if the market capacities of individual countries could be pooled. Some developing countries have preferred the domestic market-oriented strategy which is characterized by a very low rate of growth but stronger inter and intra-sectoral linkages resulting with more self-reliant development.

Another important factor that should be considered, when setting strategies of development of the electronic industry in a developing country like Ethiopia, is the level of technology one should start with and the manner of its transfer and acquisition. In the fast-changing electronic industry direct component technology which was widely used just a decade ago, is being replaced with the high technology semiconductor technology that has proved to be cheaper and technically more dependable. Semiconductor technology has greatly reduced the number of components that go into electronic equipment and thus has made their assembly easier. But component production and design developments require high technological capabilities.

Technological transfer to developing countries can be made, at least in the beginning, through foreign investment, joint ventures and licensing arrangements until local competence, design and R and D capabilities are built up.

Considering the above, Ethiopia is presently designing an optimal strategy suitable to local conditions for the obvious aim of building up a self-reliant, fast-growing and successful electronic industry.

6. Conclusions and Recommendations

The case of the Ethiopian electronic scene, roughly outlined in the preceding sections illustrates the important role that electronics play even in developing economies. Like it or not, any country cannot do without increasing applications of electronics in this modern interdependent world. Modern development requires wider and wider applications of electronics, especially in the areas of manufacturing, communication and management.

Hence, developing countries should give priority to this important and dynamic sub-sector, enhance its usage, assess their requirements, devise proper policies and strategies and pursue a self-reliant development of the sub-sector.

The ever-developing micro-electronics increases productivity, raises efficiency, improves quality, enhances education and, in general, makes life easier. All developing countries should exploit this to their utmost capabilities.

Table 1 - Import of electronic products into Ethiopia: 1977-1980

	SITC No.	Product	Value in Birr			
			1977	1978	1979	1980
1.	751.210	Calculating machine	1,086,772	561,445	253,981	542,377
2.	751.230	Cash register	41,420	35,065	43,669	17,110
3.	751.220	Accounting machine	268,192	421,960	17,744	110,516
4.	752.000	Automatic data processing	832,342	678,765	905,834	468,119
5.	761.110	TV broadcast receiver	717,640	88,543	80,814	927,028
6.	762.110	Radio receiver	4,708,832	2,160,058	1,564,107	2,090,588
7.	762.111	Other radio receiver including radiograms and cassete	2,920,817	1,515,580	358,988	686,641
8.	763.110	Gramophones	184,165	11,250	9,903	52,009
9.	763.180	Record player tape and deck	1,754,940	542,936	149,343	469,227
10.	763,800	Other sound recorders and reproducers	244,840	48,803	59,838	59,716
11.	764.110 and 764.310	Electric line telephone and telegraphic apparatus, microphones and loudspeakers, radio broadcasting apparatus, television transmission apparatus	5,207,937	12,479,871	1,552,842	2,562,112
12.	764.820	Other television video cameras	11,795	300	9,375	6,475
13.	764.831	Radio navigational aid apparatus	2,212,929	2,562,104	66,650	206,576
14.	764.832	Other radio navigational apparatus, radar, etc.	11,538	56,818	39,905	9,120

(cont'd)

Table 1 (cont'd)

	SITC No.		Value in Birr 1977	1978	1979	1980
15.	764.910	Parts n.e.s.falling within heading 764.110	16,081,935	11,507,118	10,174,456	6,959,640
16.	764,920	Parts n.e.s. of the appartus falling within heading 764.210	35,085	113,066	521,208	148,036
17.	764.931	Radio spare parts	540,837	1,387,853	6,017,044	3,319,127
18.	764.990	Parts n.e.s. of the apparatus and equipment falling with 763.	2,350,559	956,332	1,826,434	204,384
19.	776,000	Radio values,tubes and transistors	8,488	2,499	56,319	52,582
		Total Imports	39,221,063	35,130,366	23,708,534	18,891,383

Table 2 - **Demand for Selected Consumer Electronics Products**

Selected Electronic Products	1984 Population (PCs)	Annual Demark in Pcs		
		1985	1990	1994
1. Radio Sets	1,600,000	20,000	172,275	230,068
2. Tape-recorders		18,000	25,841	34,510
3. Television	45,000	9,000	22,395	46,438
4. Telephone sets	107,385	8,913	14,381	19,784

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MICROELECTRONICS AND INFORMATICS POLICY FOR DEVELOPMENT IN KENYA

a note prepared by the UNIDO secretariat*

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1. Microelectronics and industrialization of Africa

Microelectronics is a technology which is already having a major impact on industries and service sectors in developed countries and is gradually flowing into the developing countries in view of their dependence on the developed countries for most manufactured goods. But its adoption in the African countries cannot be left to chance. The potential is considerable but possible adverse results could also be serious, if care is not taken.

A large number of the products and processes used in Africa will contain more and more microelectronic products in the future, requiring, on the part of Africa, the capability to use and maintain them in appropriate systems. In addition, recent advances in microelectronics have given microprocessors and microcomputers precisely those advantages that make them appropriate for use, customization, development and manufacture in developing countries. It is important, therefore, that African countries and regions should make efforts to enter this technology in time in order to cope with the inevitable involvement which is sure to result. This is a matter of great urgency. Given the explosive revolution already underway in terms of complexity and variety of available microelectronics components and systems, those who fail to enter the technology at the early stages will face a much more difficult challenge in the future and, consequently, a much greater likelihood of finding themselves locked into a condition of dependency. The implication for Africa is that steps should be taken expeditiously to prepare for this new technology and to ensure the proper role for African nations in microelectronics as an element in their strategies for technological development. This should take cognizance of the negative effects microelectronics can have and the need for seeking ways of avoiding them.

Microelectronics could play a significant role in the industrialization of Africa, with applications which can contribute to virtually every field such basic needs as food production and distribution, health, education, industry, services, etc. In most sectors of industry as well as in some of agriculture, effective progress and competitiveness are not achievable without appropriate microelectronics applications. The most important advantages seem to be the decreased need for middle level technicians and workers, (which is a

bottleneck in most African countries), energy savings in all productive sectors, and the design and production of new products with versatility not achievable without utilization of information technology.

The economic and social conditions should be considered, including possible adverse implications, extending mostly to employment. Besides that, utilization of products based on microelectronics should be considered only where they provide real advantages to the producer or user. The transfer of the right technologies matching the needs and aspirations of African countries should be a crucial element in the technology policies. With limited financial resources only those technologies should be transferred, which allow the building of local capabilities and increase existing and future production quality and volume of products. More detailed discussions can be found in several UNIDO publications, such as "Prospects of Microelectronics Application in Process and Product Development in Africa", (UNIDO/IS.331) by M. Radnor, and "Microprocessor Applications for Developing Countries" (UNIDO/IS.351) by J. Oliphant.

Strengthening of research, development and manufacturing capabilities in the field of microelectronics requires suitable institutional infrastructure, a certain level of relevant expertise and some capital investment. The present reality is that none of these is available in most African countries. The prime requirement is building up the necessary human resource capacity.

A major problem, which has to be dealt with at the national level, is the integration of informatics technology in the mainstream of production. International and regional action may be, however, essential in providing models for such integration, as well as promoting, developing and demonstrating specific technologies, products and processes. As microelectronics-based information control products can be made cheaply from standard, off-the-shelves components, which can be customized by the user, training of the skilled staff, which may adapt products to African countries environment, is one of the most important factors of informatics development. The developed products can be very reliable, less sensitive to changes in environment and hard use, easier to develop and expand modularly, and better to withstand inadequacies in other systems, skills and materials. The

development of products and their applications should not be viewed as an isolated problem, but the appropriate governmental policies should integrate them especially in the priority sectors of national economy.

It is now broadly recognized in developing countries that, while the capacity to develop and utilize applications is an important step in the introduction of microelectronics for socio-economic development, attempts to develop application should be accompanied by efforts to develop design and manufacturing capabilities according to needs and ultimately the development strategies of each country.

The Expert Group Meeting on the Implications of New Technologies in the Implementation of the Lagos Plan of Action and the Programme for the Industrial Development Decade for Africa, held at Mbabane, Swaziland, from 22 to 26 October 1984 (Report UNIDO/OED.137), underlined the importance of African countries acquiring a capability in the field of micro-electronics.

2. Policy framework for national action

A microelectronics policy framework in a developing country may involve the following components, the sequence depending on the situation of each country and fitting into its specific socio-cultural context:

Monitoring and awareness:

(a) Monitoring on a continuous basis, through a multidisciplinary national team, the developments in microelectronics technology and its impact on priority areas in industry and other sectors, in particular in terms of skill and infrastructure requirements and comparative advantage in international trade;

(b) An awareness campaign directed to a target audience of decision-makers and end-users.

Endogenous capacities and applications:

(c) Promotion and establishment of a microelectronics industry, ranging from assembly to design and manufacture of chips and instrumentation on the one hand, and the manufacture of components on the other, the actual feasibility being dependent on local requirements and applications, comparative advantage, technological capabilities and other relevant factors;

(d) Promoting applications, based on identified national tasks, in priority areas in industry and other sectors, including the accessing, handling, processing and use of information;

(e) Short-term and long-term programmes of education and training in hardware and software, to meet local requirements and, where possible, for exports; existing programmes and institutions should be kept under review and reoriented as appropriate;

(f) Setting up or encouraging applied R and D, particularly in the fields of special applications on importance, including the training and sensitization of R and D personnel in those fields; special attention should be paid to the possible applications of microelectronics for the development of rural areas, the satisfaction of basic needs and for finding solutions to other particular concerns of developing countries;

(g) Setting up and/or linking national institutions to develop endogenous capacities and applications mentioned above;

(h) Reviewing or formulating appropriate policies for transfer of technology and investment and the encouragement of endogenous capacities and applications;

Review:

(i) Keeping under review the implementation of the several elements of the strategy and ensuring coherence and consistency of the strategy with overall development aims and other sectoral strategies, in particular a telecommunications strategy.

The above framework should be characterized by a systems approach and long-term planning and should, to be effective, incorporate appropriate co-ordination mechanisms.

Each of the elements of the framework have to be elaborated into a series of measures depending on each country's conditions. To illustrate, hardware development may require government financing of the development; bank loans for software industry; tax concessions; compilation of a programme

register to avoid duplication and promote distribution of available programmes; protection of software. Promotion of applications may require identification of priority applications; applications in small enterprises; and applications in central and local government offices. Improving human resource environment may include training informatics specialists; computer-aided learning; awareness programmes for the general public.

The actual operation of the policy framework would depend for its success on continuous monitoring and review. Within the framework certain key issues will have to be decided upon. There are referred to below.

One major issue would be whether to enter into manufacture in addition to applications. Arguments have been advanced that manufacture will be skill- and capital-intensive and not possible for developing countries. While the point of entry should be decided by each country keeping in mind the feasibilities in terms of investment, skilis and infrastructure requirements, there are countries whose manufacturing efforts would extend to the production of chips, instruments and related equipment and yet others whose efforts might have to be limited to assembly-type activities and/or manufacture of peripherals. Attempts to develop applications, it is pointed out, should not be at the expense of efforts to develop, design and manufacture components; without these efforts mastery of the technology is not possible. This has become all the more necessary due to technological trends which increasingly incorporate added value in the components and erase the traditional distinction between hardware and software.

Efforts to develop applications would create a demand base for manufacture and also obviate imports of applications from abroad. Though application areas are known to some extent, setting up of criteria for applications by each country may be necessary to focus efforts. Broadly, these criteria would relate to (a) areas that would enable the country to maintain, improve or create competitiveness in the international markets; and (b) critical areas of internal demand including those which will improve the quality of life in areas such as transportation, health, education etc. In this sense, the criteria for applications should be derived from a diagnosis of the needs and ultimately from the development strategy of each country. The public sector and public services are areas which hold out potentials for

applications. The operations in public services (for example, wagon turn-round in railways, berthing of ships in ports) could be considerably improved through microelectronics applications, but some systems may not be transferable to developing countries.

Any programme on applications has to be based at the country level on a detailed survey of the potentialities in several sectors of the economy. Such surveys should take into account the socio-economic aspects and problems of acceptance by producers and users. A close interaction between electronics professionals and users will be necessary to ensure successful application.

Building up of technological capabilities should occupy a central place in any policy framework. The concept of technological capability may have to be looked at de novo in the context of microelectronics. The developing countries will, among others, require capabilities in the field of electronics manufacture and assembly; while such capabilities are not totally different from manufacturing skills in general, the capabilities required for applications of microelectronics are non-existent in most developing countries and are lagging behind hardware development even in the developed countries. Software capabilities will be critical. The manpower required will include programme designers, systems analysts, data-base designers, programmers, controllers and managers, in addition to the more basic specialists in operations research, mathematical logic and scientific management. The objective in the development and use of software should not be only to meet routine requirements but to promote the design of applications for local problems and also to serve an export market where possible. In the final analysis, the actual impact of microelectronics on developing countries will be largely determined by their capacity to develop and apply software.

Software should be looked at in the broader sense of the requisite technological capabilities and should not be confined to select groups of programmers, systems engineers and operators. These specialized skills are crucial, of course, but it is equally important for developing countries to try to develop a software/microelectronics consciousness among as many people as possible. Persons working in all fields must be trained and encouraged to think about the potentialities of microelectronics for their own activities and to recognize that pre-packaged technology could be unpackaged to serve

local needs as perceived by themselves. Much of the software ought to be developed in the culture in which it is to be applied. Innovative training programmes starting from familiarization with computers at the school-level would be needed in addition to learning kits, micro-informatics clubs etc. Several developed countries and some developing countries, like Singapore, have initiated such programmes. Investment in human resources will be the most important key to realizing the benefits of microelectronics. If the infrastructure for application of microelectronics is created the benefits could be expected to come sooner. The term 'infrastructure' should be looked at in broad sense, including repairs, maintenance and service facilities and, above all, an industrial milieu which permits and provides microelectronics applications.

Education and training are therefore the key areas to which policy action should address itself. This would require not only an inter-ministerial effort but also interactions with the academic community. Given the socio-economic nature of education, innovative but carefully formulated policy directives from the highest levels in government will be needed to initiate the necessary changes and allocate the requisite resources.

It is possible to organize a centre for microelectronics application. A centre like that should conduct its activities in such areas as:

- Research and development including the elaboration of the mechanism of implementation of results in industry;

- Training and upgrading the professional skills of manpower;

- Collecting and dissemination of information from the field;

- Maintaining the connections with the relevant research institutions in the region and internationally.

If the local conditions and constraints are not favourable enough to create a centre for microelectronics applications, then a core-group model on selective applications may be more appropriate. A group may consolidate

around the the existing institutions, e.g. a university, concentrating its activity on the selected problem or set of problems and in this way solving tasks which are important for the country's economy. An approach like that is more elaborated in "Microprocessor Applications for Developing Countries" (UNIDO/IS.351) by J. Oliphant.

While human resource development would belong to one of the longer term measures, certain short-term measures would also need attention. One key area in this respect is the policy for public purchases. The purchase policies for computers, telecommunications and microelectronic equipment in several developing countries would at present appear to be uncoordinated. Apart from avoiding possible distortions, the purchasing power of the government could be considered as an important tool and utilized for the development of national industries and technological capabilities.

3. Requirements and policy measures for Kenya

There is a need for short- and long-term measures. Short-term measures include monitoring policies for acquisition of technology and for public purchases. The most important requirement in the long term is that for skills. Four types of skills are required. The first is the type of skills required for identifying and specifying applications of microelectronics. The second type of skill, and the predominant one for development, is for software identification, adaptation and development. The third type of skill is for promoting wide adoption of microelectronic systems among local users. The final type is for service and maintenance of microelectronic systems.

In designing policy measures aimed at implementing programmes to stimulate and facilitate appropriate use of microelectronic systems in Kenya, the following general principles must be borne in mind:

(a) Application approach should begin by being practice-up. Applications should begin with well-identified microelectronic candidate user needs and current practices, or with such products, processes or services that are already in use or being locally produced, and could be performed by a core production group identified through the needs.

(b) It is essential to develop methodologies for optimally promoting and disseminating the programme structurally as well as operationally. A linked regional structure plus a "learning and improving by doing" strategy (that moves through a use, make, improve and innovate cycle) should be considered.

(c) Every effort should be made to harness and exploit any appropriate sources of technology assistance from other developing countries (in a TCDC mode) as well as from developed nations.

(d) The programme must build up a self-sustaining capacity through lagged but concurrent efforts utilizing training (in Africa and elsewhere) as well as the build-up of experience and confidence among users as well as producers.

Having regard to the foregoing considerations and the possible components of a framework for national action indicated in chapter two, the meeting may consider identifying the content and modalities of a possible framework for national action in Kenya in the field of microelectronics. Within that framework there could be:

(a) A set of government policies to monitor acquisition of technology and public purchases as well as for the development of an endogenous capability in this field;

(b) Specific programmes of action, such as in the field of human resources development and other relevant areas, preferably in the form of a plan of action to be implemented by the concerned agencies and institutions;

(c) Possible institutional arrangements for developing endogenous capability such as interdisciplinary core groups or a centre for microelectronics application.

As already emphasized, the elements of action to be finally undertaken should be closely related to the development objectives of Kenya and its present socio-economic conditions.

4. International co-operation and role of UNIDO

International and regional co-operation should result in the establishment of a mechanism to continue the exchange of information, consultation, advice, etc. In several regions UNIDO assists in the promotion of regional co-operation in microelectronics and informatics. As a result of the UNIDO/ECLAC activities, the Latin American Microelectronics Network (REMLAC) is being created. Also as a result of the co-operation between UNIDO and ECWA, a microelectronics meeting was organized in Kuwait, and co-operation among the countries of the ECWA Region was sensitized. A network is being established in that region also. In November 1984, an Expert Group Meeting on the Implications of New Technologies in the Implementation of the Lagos Plan of Action and the Programme for the Industrial Development Decade for Africa took place in Swaziland, and special attention was given to microelectronics applications. UNIDO prepared several studies to assist developing countries in establishing indigenous capabilities in the field of informatics. The "Guidelines for Software Development in Developing Countries" (UNIDO/IS.439) by R. Narasimhan, give an outlook on policy preparation in the field of informatics. The studies "Software Engineering: A Survey" (UNIDO/IS.446) by W. Turski, and "Guidelines for Software Production in Developing Countries" (UNIDO/IS.440) by H. Kopetz, as well as "Problems of Software Development in Developing Countries" (UNIDO/IS.383), prepared by the UNIDO Secretariat, present the software possibilities for developing countries.

In the scope of international co-operation, UNIDO may provide technical assistance and advisory services, as required by African countries, for the establishment of microelectronics assembly/manufacture and the development of human and institutional capabilities, in particular software and the basic design. The concepts such as microprocessor applications centres and core groups for software and design may be particularly relevant for implementation in the African context UNIDO may also promote co-operation among African countries. Applied research and development of hardware and software related to microelectronics and its applications may be the subject of co-operation. In the field of public purchases of equipment and components as well as acquisition of technology, UNIDO may promote exchange of information among African countries and provide advisory services as required. UNIDO may also provide advisory services for policy formulation, if requested, including the preparation of programmes and plans.

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THE PROSPECTS FOR SOFTWARE PRODUCTION IN DEVELOPING COUNTRIES*

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INTRODUCTION

This paper deals with the advancement of the information industry, particularly of the software industry in developing countries. In the first part three phases of information system development are distinguished. The successful implementation of one phase is considered to be a prerequiste for the start of the following phase. In the final part concrete policy recommendations relating to the software sector are presented.

In the long term, any industrial activity can only be successful if it is satisfying the needs of the people. This general observation applies to the information industry as well as to any other industrial sector.

The development of the Information Industry in any country must therefore be coordinated with the general industrial development and must contribute its share to the national priorities.

In the developed countries, the information industry is one of the most important economic growth sectors. Its main contributions are in the area of business operations, however it is also directly affecting many other spheres of the society, e.g the education system, the communication patterns and the consumption of information and entertainment in the home.

The importance of the information sector for the advancement of a society, developing as well as developed, cannot be overstated. The information industry is primarily a knowledge based industry. Therefore the availability of skilled technicians and wellinformed experts is more important for the development of this industry than large capital resources. The most important aspect of information technology development is knowledge generation. It follows that different policy actions are relevant depending on the level of development a society has achieved so far.

It is inappropriate for this author to define the national objectives and the role of the information technology in this context. However, it will be shown that the advancement of the information industry critically depends on a number of preconditions which must be realized in each phase of development.

This paper is subdivided into two parts. In the first part we will introduce three phases in the development of the information industry and discuss the resources required to implement each phase. Based on this analysis, we will outline concrete recommendations for a software policy in the second part.

REQUIREMENTS OF THE INFORMATION INDUSTRY

In the development of the information sector of the economy we distinguish between the following three phases.

(1) Introductory phase

In this phase basic know-how in the area of information technology is built up. This is achieved in a number of different ways. On the one side a core group of experts acts as a catalytic element for the dissemination of basic knowledge which is acquired from outside sources. On the other side a base of skilled technicians has to be established in order to accept and transform this know-how to information technology products which are useful for the home market. It is felt here that application software development on small microcomputers forms an ideal entrance to this first phase. Microcomputers are relatively cheap and therefore do not require much capital. The maintenance of microcomputers is much simpler than the maintenance of large machines. The growth rate of the microcomputer market is significantly higher than the growth rate of the computer industry in general. It is to be expected that by the end of 1986 the world market for microcomputer based desktop systems will surpass the the general purpose computer market. Thus the introduction of the small mass produced microcomputer corresponded to a "technology break" which will transform the information industry in general. Nations which enter the information era now can take advantage of the challenge provided by such a technology break.

The knowledge required to get the microcomputer to practical use is small compared to the knowledge required to operate and maintain the large machines. Thus it is to be expected that the results of an application software

product development will be visible and available within a fairly short period of time.

The selection of the right application area for these pilot projects in application software development is of crucial importance for the success of the introductory phase. Only if the products are contributing to the national priorities the support of this first phase will be guaranteed on a wide and undisputed base.

In a nation, which considers self sufficiency in food and the advancement of education as its primary goals, the application software products should be based on the needs in this area. For example, a small microcomputer based software package can help a farmer to calculate the optimal food composition for the animals or assist a warehouse in stock control. Small computers with the appropriate software packages can also be placed in schools in order to support the teachers and provide an environment for the advancement of general computer literacy.

The data exchange between these stand alone microcomputer systems should be based on the exchange of the data storage media, e.g. floppy discs. Depending on the availability of a communication infrastructure, the direct interconnection of these small computers should be investigated by the core group. However, since the operation of a reliable data communication service is a difficult task, no application should be dependent on the availability of such a service in this first phase.

The wide availability of these small microcomputer systems can form the starting point for a local hardware maintenance service. Although maintenance will be limited to component replacement at first, this can form the nucleus of a small hardware industry, e.g. the design and manufacture of some peripheral devices. It is very important that the core group of experts does have sufficient knowledge in such practical areas as hardware maintenance and design and is obliged to support small enterpreneurs willing to enter this new field.

The resources required to implement this introductory phase are the following:

- A core group of 10 to 20 experts which are knowledgeable in the fields of computer applications, software design, hardware maintenance and hardware design. The implementation of the first pilot projects is the responsibility of this core group. This core group is also responsible for the selection of application areas and user education.

- Capital in order to provide the core group with computers and a state of the art software development environment and a sufficient number of personal computers to operate the application software at the end users. The equipment which is necessary in order to test and maintain the microcomputers must also be provided.

(2) Intermediate phase

In addition to the delivery of useful application software products the most important result of the first phase is "know how generation" in the area of computer literacy in general, programming, hardware maintenance etc.. The widespread availability of this know how is a prerequisite for entering the second intermediate phase of development. The second phase of this development plan is more know how and capital intensive than the first phase. Only after a sufficient number of skilled technicians has been trained in the first phase and a general insight into the benefits and limits of computer applications is available among a sufficiently large number of potential end user does it make sense to enter this intermediate phase. Otherwise the significant capital resources, which are required for this second phase will not be used to their full potential.

This second intermediate phase can be considered the "core" phase of information system development. On the software side, the many small microcomputer systems should be interconnected, both offline and online to realize synergetic effects. Some central data bases will be built to support the decision making of the government and industry. Know-how in the operation of large computers with complicated operating systems and telecommunication systems has to be acquired. An important application area which has to be entered in this second phase is the development of real time systems for data collection and process control. These real time systems can improve the operation of industrial plants, thus reducing the material and energy consumption and the pollution. In our opinion it is important for the developing

countries to be sensitive about pollution effects to the environment at an early stage so that the immense capital resources which are required to clean up the environment after it has been polluted can be saved. Computer technology, particularly real time control of industrial processes can contribute significantly to realize these goals.

The software development in this second phase will not be limited to application software development. Real time control requires an insight into operating systems, data communication and man machine interactions. These capabilities should be introduced and realized in pilot projects by the core group of experts which must be expanded in this second phase.

On the hardware side the maintenance activities can be expanded into a small computer industry with the capability to assemble and later on design microcomputer system at the Printed Circuit board level with standard components. A joint venture with one of the computer companies which supplied the microcomputers of the first phase is an effective way of technology transfer. In the second phase the economy can achieve a fairly high level of self-reliance in the area of information technology. Components are bought from the world market (they only represent a small fraction of the value of a complete computer application), assembled, programmed and maintained within the country. Most of the value of information system development will be added within the country.

At the end of the second phase, after a sizeable home market for hardware products has developed and enough expertise in hardware design, assembly and testing has been acquired, the Very Large Scale Integration (VLSI) field for the production of microelectronic components can be entered. Two stages must be distinguished when entering the VLSI field. The first stage comprises the design of VLSI components only. At this stage the production is still with some outside supplier, i.e. a "silicon foundry". In the second stage the production of VLSI components is also accomplished within the country. It is strongly recommended here not to start the production of VLSI components until a wide market and sufficient know-how in the design of VLSI circuits is available. Therefore VLSI production should be left to the advanced phase of information technology development.

The resources required for this second phase of information technology development are substantial:

- Information system technology must be integrated into the education system at all levels. Information system topics should be included in the general education in order to increase the awareness for the benefits and limits of computer technology and thus increase the "computer literacy" of a wide audience. The training of skilled technicians at the intermediate level in vocational training schools is of utmost importance. At the University level "centers of excellence" must be created for the training of the teachers and for keeping contacts with the international research community. The core group of experts for the introductory phase will form the nucleus for these "centers of excellence" and has to be expanded to cover all topics which are introduced in the second phase of development.

- Marketing channels to sell the information system products produced locally must be established. The maintenance organizations must be expanded to cover all products introduced in the second phase, software and hardware. Policy actions, which limit the variety of products can help to reduce the maintenance effort and increase the productivity of the normally scarce skilled labor force.

(3) Advanced phase

The know-how acquired and generated during the intermediate phase is a prerequisite for a successful start of the final, the advanced phase of information technology development. In this phase of development the information sector matures to a level which corresponds to the state of the art of information technology worldwide. In the industrial sector, information system products (hardware and software) will be exported under international competitive conditions. In the academic sector the "centers of excellence" contribute and expand the international state of the art of information technology.

On the software side the development of complex real time systems and expert system is characteristic for this third phase. A fully developed and reliable communication infrastructure is a prerequisite for the interconnection of the different decentralized computer systems. Electronic mail and office automation systems gain widespread acceptance. A high percentage of the work force will be using the computer systems in one way or another.

On the hardware side, the home production of the VLSI components, which have been developed in the second phase is started. The technical infrastructure which is required for the successful fabrication of VLSI components is enormous. The continued maintenance of the complex mechanical and electrical equipment which is necessary for VLSI production requires a large number of very skilled technicians. The media (liquids, gases) required for microelectronic factories must conform to the highest quality standards. If the quality of the clean room environment is not maintained, serious production losses will result.

The following table gives an overview of these three phases of information technology development:

Phase	Software	Hardware	Infrastructure
Introductory	Application Software on Microcomp. Data exchange via media	Microcomputer acquired from outside	small core group of experts maintenance capability developed
Intermediate	Database appl. Real time communication System Softw.	Assembly of small computers and Peripherals VLSI design	Education at all levels Centers of excellence created
Advanced	Complex Real Time systems Expert system	VLSI production	Communication infrastructure High level of general technical infrastructure

POLICY GUIDELINES

The information policy which has to be formulated and executed in a country depends on the level of the information sector. In the following we will concentrate on policy guidelines for the introductory phase of information system development, as outlined before.

In this phase the application software development on Microcomputers is the first and primary activity. The following topics have to be addressed

-Software development center
-Economic climate
-Education
-Standards

(1) Software development center

A small and effective group of experts forms the starting point for the national software effort. This group of experts should be located in a Software Development Center which is responsible for the specification of a detailed software development plan, for the implementation of pilot projects and for the training of teachers, programmers and end users.

These experts can be recruited from local people who have been trained in suitable environments within the country or abroad or from outside consultants. It is important that the skills in this core group of experts are practical as well as theoretical. In addition to a solid background in software engineering these people should also have project management experience, communication, didactic and legal skills. A small number of the people in the core group should also be hardware oriented, as mentioned before. The expertise in this core group should be sufficient to program and maintain the computer systems which have been selected.

At the beginning, this core group of experts should be located in a Software Development Center with the necessary equipment for Software Development. Such an equipment consists of workstation Microcomputers and a software development environment. The necessary equipment for hardware maintenance to the printed circuit board level should also be provided.

In addition to the implementation of pilot projects, the Software Development

Center should provide the following services:

- Monitor the market of information industry products and new trends and developments. This will provide valuable background information, both for the political decision makers and software developers.

- Formulate and, after approval, execute an initiative to promote general "computer literacy". A necessary prerequisite for the success of a new industry, such as software, is a general public awareness for the potential, the capabilities and the risks involved.

- Initiate a research program on information science and specifically on software technology.

- Support interested individuals and startup companies in the area of software technology with economic and legal advise, as well as with some financial assistance.

- Set up the legal framework for the introduction and execution of standards for the information industry. Standardization of hardware, software and the associated documentation can substantially reduce the maintenance costs for information industry products and improve the compatibility of the different systems.

(2) Economic Climate

If we analyse the world-wide market for application software, we will find out that this market has some characteristics of a "cottage industry". Small companies and sometimes even single consultants play an important role in this market. If the startups in the area of application software are to be successful, it is necessary to provide a climate in which such a "cottage industry" can blossom.

In addition to the technical support which is given to these new entrepreneurs by the Software Development Center the legal and financial climate must be such that motivated people are willing to take the risk of forming their own small company for software production or computer system maintenance.

The rules and regulations concerning software acquisition by the government or other public organization should encourage small local companies to participate in software projects.

(3) Education

An important result of an active Information Policy is the general advancement of computer literacy in a society.

It must be the goal of a computer literacy initiative to bring a high percentage of the youth in direct contact with computers and software at an early age. Personal computers should be installed in all schools and students in the age of ten upwards should have the possibility to use these machines in their mathematics and science classes. Experience has shown that students of that age have no problem in mastering the computer. If there is some lack of trained teachers, computer assisted instruction courses, which run on these small machines, can fill part of the gap. Students, which thus develop a natural relationship with the computer, will have no difficulty in integrating the computer into their workplace at a later stage.

While it is important to introduce computers into the general education system as early as possible, the retraining of parts of the active workforce must not be overlooked. Many job profiles are changed because of the introduction of computers. It is irresponsible to fill new job positions with new people only and to push those workers, who do not have the necessary knowledge in the new technologies, aside. The persons, who have worked in a given position for a number of years, have gained valuable job experience which, combined with some software knowledge, is an important asset to society. The computer and software training of the adult population must thus be included in the training programs.

Teaching computer and software technology without the possibility of practical work on the machine is a dangerous undertaking. Since the lectures tend to become too theoretical, the student will not grasp the elementary concepts and might shy away instead of developing a positive attitude towards this new technology.

Therefore any software education initiative must be supported by an initiative to provide the necessary computer hardware for the practical software training on the machine. As mentioned before Microcomputers form the recommended hardware base for this practical training. A detailed outline

for a software engineering curriculum is contained in the UNIDO report referenced below.

(4) Standards

At the moment, there are so many different companies offering microcomputer systems and software that some restraint is necessary. Otherwise the effort for training and maintenance will become unacceptable.

In the first phase of the information sector development only a small number of information system products should be included in a national standard.

The standards should cover the following areas:

- Microcomputer Hardware and Peripherals
- Operating Systems
- Programming Languages
- Data Communication Protocols.

A detailed discussion of these standards is contained in the UNIDO report "Guidelines for Software Production in Developing Countries" by H. Kopetz, UNIDO/IS. 440 February 10, 1984.

POLICY RECOMMENDATIONS

(1) Establish a core group of 10 to 20 experts with theoretical and practical expertise in the following fields: software engineering, hardware maintenance, application know how, application software development, organizational and legal skills.

(2) Select a small list of Microcomputer models. Evaluate the models and standardize on two or three. Standardize the operating system and programming language.

(3) Establish a maintenance organization for the standardized hardware. This can be in cooperation with small industry. It is important that the training and spare parts for this maintenance organization are fully secured.

(4) Identify an application area which is at the center of the national priorities and which can be effectively supported by a standalone Microcomputer application.

(5) Initiate a pilot project on application software development in the selected application area with strong user participation. Closely monitor the progress of this project. After completion of this project implement the application on a broad scale. It is important to provide excellent user documentaion, end user training and a "hot line" for maintenance in hardware and software.

(6) Provide a large number of the selected Microcomputers to the Educational Institutions, i.e. Universities and vocational training schools. The cooperation between these educational institutions and the core group is to be established.

(7) Establish a training program for software engineers and teachers at the University. Introduce courses on computer programming and software development into the vocational training schools. All courses must have a substantial section of practical laboratory work.

(8) Initiate a program for the financial, organizational and legal support of independent software consultants and small companies. Provide these institutions with the selected microcomputer equipment. Support these institutions with free training courses.

(9) Ascertain that the acquisition of software and computer systems by the government and other public or semipublic agencies is open to these small entrepreneurs.

(10) Establish regional centers for information technology. Introduce a research program in software technology. Initiate a "computer literacy campaign" at all levels of the educational system.